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UW-CIMSS proposed to ONR to investigate advanced methodologies from satellite-based remote sensing to improve observations over data-void regions of the mid-latitudes. Based on two field program opportunities, CIMSS provided enhanced satellite-derived products in support of mission planning, and for post experiment analysis. The results were deemed highly successful from both experiment organizers, as well as from quantitative evaluation based on numerical model impact studies.

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Summary of Accomplishments

The Cooperative Institute for Meteorological Satellite Studies proposed to investigate advanced methodologies from remote sensing to improve observations over data-void regions of the mid-latitudes. The meteorological targets of interest were specifically centered on two field programs aimed at improving the analysis and forecasting of extratropical cyclones. The major accomplishments of this study are briefly summarized below:

1) Satellite datasets were successfully collected and processed (mostly in real time) during the two field programs, FASTEX and NORPEX

2) Case study datasets were identified by the respective field program communities for further analysis and these were carefully prepared, packaged and disseminated to colleagues/collaborators.

3) Web site home pages were set up during each field program for real time mission planning, and post-experiment dataset analysis. These sites remain active and are still being accessed:
http://cimss.ssec.wisc.edu/fastex/fastex.html
http://willy.ssec.wisc.edu/~caljet/

4) The satellite-derived datasets were successfully employed in real time at the respective field experiment sites. The data were used in mission planning, to adjust targeted sampling strategies, and to describe the initial conditions for subjective nowcasting and short-term forecasting. In this regard, the project objective of operational demonstration was a success.

5) Selected datasets from FASTEX and NORPEX were distributed to the modeling groups at NRL-MRY and NPS for evaluation on model impact in NOGAPS and MQ-NORAPS, respectively. Successful assimilation of the data was accomplished in each system.

6) Results of the global model data impact experiments were positive. All FASTEX cases resulted in a reduction of mean forecast error in NOGAPS. For the NORPEX period, the 48-hr NOGAPS forecasts errors were reduced by a full 21% over a western North America verifying domain. These results were supported by ECMWF model data impact experiments which showed positive impact on 3-7 day North American forecasts over a two week NORPEX period after assimilation of the CIMSS satellite wind data.

Project Objectives and Results

Objective A: Develop prototype products from satellite-based sensors that yield tropospheric information over data-void regions.

Results:

1) Observations from GOES, GMS and NOAA satellites were collected and processed into meteorological variables on a continuous basis during the FASTEX and NORPEX oceanic field programs. The quantities include primary variables such as winds, and derived fields such as total precipitable water, cloud height analyses, and upper-level thermal advection and divergence.

2) The experimental processing routines were fully automated and represented advanced algorithms developed at CIMSS. The resulting datasets were greatly enhanced both spatially and temporally over operationally-available datasets.

3) The primary variable derived for demonstration and applications was high-density winds produced from multispectral GOES and GMS imagery. The winds were derived from high-resolution visible, IR and water vapor imagery. The resulting vector field coverage was an order of magnitude greater than operationally-available coverage, and of higher quality.

4) As a result of the demonstrated success and impact, the satellite-derived winds software is being converted to operate on Navy-designated workstations. The porting will include both DoD global processing centers and regional sites. This will allow in-house operational processing of the quantities and derived products demonstrated as part of this research study.

Objective B: Demonstrate the real time derivation of these products for use in field experiment mission planning and forecasting, to simulate an operational setting.

Results:

1) The datasets mentioned above were processed at UW-CIMSS and made available in near real time via the Internet to the FASTEX operations center in Ireland, and the NORPEX operations center in Monterey. The datasets were processed to meet operational time constraints (mission planning and numerical model guidance data cut-offs).

2) The real-time processing/dissemination success rate was greater than 90% for each field program. Most of the unsuccessful datasets were due to Internet communications problems, and rarely due to processing problems at CIMSS. Real time displays of the products on the CIMSS Web site were successful at ~95%.

3) The FASTEX and NORPEX organizers and mission planners acknowledged the real time satellite products as extremely useful to mission planning, adaptive sampling strategies and short term forecast guidance.

Objective C: Use the products in concert with other data sources to examine meteorological science issues.

Results:

1) The above mentioned products are being used in FASTEX and NORPEX case study analyses by Dr. Mel Shapiro (NOAA) and collaborators. The dynamics and structure of developing extratropical cyclones is the focus. Both analytical and modeling issues are being studied. Dr. Shapiro has acknowledged the important contribution of the satwind data to the detailed analysis of these events in many of his public seminars.

Objective D: Examine the impact of the satellite data in data assimilation systems, objective analyses and numerical forecasting systems.

Results:

1) The advanced satwind products have been successfully assimilated into 3 objective analysis systems: NOGAPS, MQ-NORAPS and ECMWF 4DVAR. Each of these assimilation systems are unique. Further study will be required to optimize the assimilation of these high-density satellite winds.

2) Using NOGAPS, positive model forecast impact was found in four of five FASTEX IOP forecasts of extratropical cyclones (one neutral impact) after assimilation of the enhanced GOES winds over the Atlantic. The forecast improvement was significant in three of the IOP cases.

3) Neutral forecast impact was found in one FASTEX IOP case study employing MQ-NORAPS. However, in this particular case the control forecast without the enhanced satellite data of the target storm was already quite good. Notable changes in storm structure were analyzed when the GOES multispectral winds were included. Further evaluation is underway.

4) Substantial positive model impact was found after assimilation of the enhanced North Pacific satwinds in NOGAPS forecasts over western North America for the 6 week NORPEX period. The overall 48 hr forecast improvement for the 6 week period using a prescribed total energy error norm was 21%.

5) ECMWF used their latest 4DVAR analysis system and high resolution forecast model to assimilate and test the impact of the enhanced satwinds for a two week period during NORPEX. The preliminary results indicate a positive (5-20%) forecast improvement in the 3-7 day range over North America.

List of Publications and Presentations Supported by this Project

Refereed Publications

Gelaro, R., R.H. Langland, G.D. Rohaly and T.E. Rosmond, 1998: An assessment of the singular vector approach to targeted observing using FASTEX dataset. Quart. J. Roy. Meteo. Soc., in press.

Goerss, J.S., C.S. Velden and J.D. Hawkins, 1998: The impact of multispectral GOES-8 wind information on Atlantic tropical cyclone track forecasts in 1995. Part II: NOGAPS forecasts. Mon. Wea. Rev., 126, 1219-1227.

Langland, R.H., R. Gelaro, G.D. Rohaly and M.A. Shapiro, 1998: Targeted observations in FASTEX: Adjoint-based targeting procedures and data impact experiments in IOPs-17 and 18. Quart. J. Roy. Meteo. Soc., in press.

Langland, R.H. and co-authors, 1998: The North Pacific Experiment – (NORPEX-98): Targeted observations for improved North America weather forecasts. Bull. Amer. Meteo. Soc., in review.

Velden, C.S., T.L. Olander and S. Wanzong, 1998: The impact of multispectral GOES-8 wind information on Atlantic tropical cyclone track forecasts in 1995. Part I: Dataset methodology, description and case analysis. Mon. Wea. Rev., 126, 1202-1218.

Velden, C.S., and co-authors, 1997: Upper-tropospheric winds derived from geostationary satellite water vapor observations. Bull. Amer. Meteor. Soc., 78, 173-195.

Conference Proceedings

Langland, R.H., R. Gelaro, G.D. Rohaly and M. Shapiro, 1998: Adjoint-based adaptive observations in FASTEX. Symp. on USWRP Research Foci, Phoenix, AZ, January, 1998.

Rohaly, G.D., R.H. Langland and R. Gelaro, 1998: Identifying regions where the forecast of tropical cyclone tracks is most sensitive to initial condition uncertainty using adjoint methods. 12th AMS Conf. Num. Wea. Pred., Phoenix, AZ, January 1998.